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Evidence-Based Kernels: Fundamental Units of Behavioral Influence

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Abstract

This paper describes, evidence-based kernels, fundamental units of behavioral influence that appear to underlie effective prevention and treatment. Identifying, classifying and evaluating these units could contribute to an empirically based theory of behavioral influence, facilitate the dissemination of effective prevention and treatment practices, clarify the active ingredients in existing interventions, and contribute to the more efficient development of more powerful interventions. Kernels have a recursive internal and external structure involving antecedents (discriminative stimuli), relational frames for responding involving language, discrete behavioral steps, and proximal consequences quickly. Kernels are parsimonious in describing how humans attempt to influence each other, in the larger theory of selection by consequences. Kernels influence behavior primarily by a four-part taxonomy: mobilizing reinforcement, altering antecedents, changing verbal relational responding, or changing physiological states directly. The paper also describes a database of kernels that is available for people to register additional kernels to foster the dissemination of kernels for public-health benefits and improvement in the practice and theory of prevention and treatment.

Key words: evidence-based kernels, public-health benefits, prevention, treatment

Evidence-Based Kernels: Fundamental Units of Behavioral Influence

This paper presents an analysis of fundamental units of behavioral influence that appear to underlie effective prevention and treatment. We call these units *kernels*. They are fundamental since deletion of any component of the procedures would render them inert. Understanding them could contribute to an empirically based theory of behavioral influence, facilitate dissemination of effective prevention and treatment practices, clarify the active ingredients in existing interventions, and contribute to the more efficient development of more powerful interventions.

The ultimate goals of treatment and prevention research are reduction of the prevalence of the most common and costly problems of behavior and an increase in prevalence of wellbeing. Current thinking about how to accomplish this assumes that we will identify empirically supported programs and, to a lesser extent, policies, and will disseminate them widely and effectively. This strategy has at least four limitations. The first is the difficulty in widely implementing programs with fidelity (e.g., Ringwalt et al., 2003). The second is the failure of this strategy to foster the use of effective practices outside the narrow confines of the program. The third is program costs. The fourth is the limited effectiveness of existing programs. Specifying fundamental units of behavioral influence addresses each of these limitations.

The strategy of disseminating empirically supported programs leaves untouched practices of behavior change agents that fall outside the scope of the program. It fails to affect *any* of the practices of those who choose not to adopt a program. Teachers, clinicians, parents, healthcare providers, coworkers, supervisors, and many others are constantly trying to influence the behavior of others beneficially. If they had better information about basic behavioral influence strategies, they might be more successful in doing so, even if they never adopted a formally evaluated program. Given current evidence, it seems likely that for the near future most practices that influence human development will fall outside the scope of existing programs. Failing to improve those practices is a missed opportunity.

Yet, there are limitations even for those adopting a program. For example, a teacher may apply Life Skills Training (Botvin et al., 1995) with fidelity, but that may have no impact on other ways the teacher interacts with students. To the extent teachers learn active components of a program and find them generally useful, they are more likely to use them in other situations.

Making a set of empirically supported kernels widely available to behavior-influence agents would also reduce the cost of bringing about widespread use of effective practices. The kernels we identify are in the public domain, easy to adopt, and useful across many situations. Their dissemination requires no expensive materials. Training in their use can be accomplished much more cheaply (often simply by modeling or defining) than training in complex programs.

Identifying the fundamental units of behavioral influence would also contribute to strengthening our interventions. Eddy (2006) noted that our lack of understanding of the core components of effective interventions hampers their development. Intervention research is not contributing to the extent that it could to improving our understanding of basic psychological and social processes that interventions must target. We do not have models of preventive interventions that target social or psychological processes precisely, affect those targets, and produce effects demonstrably mediated by their effects on these psychological and social processes. As a result, we have not developed a robust and generalizable theory of the key aspects of human functioning and the ways in which to affect those aspects. We can therefore say little about how to construct new interventions in new problem areas and cannot easily communicate to nonscientists what they might do in their own circumstances. All we can say is "apply this program," but often there are no evidence-based programs to apply. A theoretical

analysis that pinpoints specific procedures that influence behavior and psychological processes would stimulate research to refine and improve these component strategies and would encourage the creation of new and more effective programs and other practices.

We organize the discussion of kernels in terms of a basic theoretical framework of human functioning and give examples of kernels across biological, behavioral, and cultural levels. We illustrate how this analysis can contribute both to the wider use of effective behavior influence procedures in society and to improvement of the efficacy of interventions.

Kernel Definition and Examples

An evidence-based kernel is an indivisible procedure empirically shown to produce reliable effects on behavior, including psychological processes (Embry, 2004). The unit is indivisible in the sense that it would be ineffective upon elimination of any of its components. Examples of kernels include timeout, written praise notes, self-monitoring, framing relations among stimuli to affect the value of a given stimulus, and increasing Omega 3 fatty acids in the diet in order to influence behavior. A kernel may increase the frequency of a behavior or it may make a behavior less likely. It can have its impact by altering antecedent or consequent events in the psychological environment of the person or it can affect behavior by directly manipulating a physiological function. Kernels, by definition, target a single behavior, whereas programs typically target multiple behaviors.

The Example of Timeout

One of the first kernels of behavior influence technology to be developed was *timeout* (Wolf et al., 1964). Dicky was a three-year-old boy with autism who had undergone surgery for cataracts. He lived in a psychiatric hospital and had frequent tantrums resulting in self-injury. In tribute to the late Montrose Wolf, Risley described this landmark study (Risley, 2005):

> *After having just discovered the power of adult attention for young children, and realizing that the staff could not simply ignore temper tantrums, especially violent ones with mild self-abuse, Wolf decided to prescribe a response to tantrums that would minimize any social reinforcing effect of the necessary attention and counterbalance that reinforcement with a period of social isolation. The prescription for tantrums was to place Dicky, calmly and without comment, in his room until the tantrum ceased and at least 10 minutes had passed. When tantrums were under control and after wearing glasses had been hand shaped, Dicky began to throw his glasses occasionally. When the social isolation prescription was applied, glasses throwing decreased from about twice per day to zero. But the hospital staff doubted that it was due to the procedure, because Dicky didn't seem to mind being taken to his room; he just rocked in his rocking chair and hummed to himself. Because throwing glasses was both less serious and more reliably measured than tantrums, Wolf agreed to discontinue the procedure—and glasses throwing soon increased to the previous level. The social isolation procedure was reinstated, and glasses throwing decreased again to zero (pp. 281-282).*

Thus was born *timeout*, shown to reduce probability of a vast range of behaviors in hundreds of studies. Timeout is a staple of nearly every evidence-based prevention program for parenting (e.g., Incredible Years [Webster-Stratton & Reid, 2007]; Triple P [Sanders & Markie-Dadds, 1996]; Parent Management Training [Forgatch et al., 2005a; b]). It is also part of popular culture. Shows like *Nanny 911* demonstrate its use; websites giving advice to parents (e.g., http://www.thelaboroflove.com/forum/quality/timeout.html) describe it. Although population-

based data on the prevalence of families and schools using timeout are not available, it appears that in many areas, timeout is the normative replacement for harsh methods of discipline.

Theoretical Kernel Taxonomy

Although simple enumeration of kernels may support effective practice, their contribution may be more substantial if we can organize them within a theoretical framework that delineates the key influences on behavior. Such a framework would facilitate generating new kernels and could point to overlooked procedures for influencing behavior.

We believe kernels are understandable in terms of the operant behavior of biological organisms, viewed within a developmental and evolutionary perspective. Human behavior—including verbal, cognitive, and emotional functioning—has developed over time as a function of the biological capacities of the organism and the consequences to behavior. Human behavioral tendencies are adaptive functions of current situations and a history of consequences for behaving in similar situations (e.g., Biglan, 1995).

Inspection of the apparent effective influence of kernels we identify finds them typically involving one of four primary processes. First, many operate primarily via provision of a consequent event affecting the subsequent probability of the behavior on similar occasions (e.g., written praise from peers or authority figures; Skinner et al., 2000). Second, a kernel may primarily involve an antecedent stimulus affecting one's motivation to behave due to a history of consequences for responding to that stimulus (e.g., a teacher's use of a standard signal to prompt students to get seated; Jason et al., 1985; Wasserman, 1977). A third type primarily involves altering the relations that people derive among verbal stimuli in ways affecting their motivation (e.g., elicitation of a public commitment to effectively associate the behavior a person commits to a network of consequences for complying or not complying with the commitment; Chassin et al., 1990). A fourth involves kernels primarily altering a biological function of the organisms affecting behavior (e.g., supplementation of diets with Omega 3 fatty acid; Haag, 2003).

Table 1 presents a list of kernels organized according to this theoretical taxonomy or framework. We categorize each kernel in terms of the primary mechanism through which it affects behavior, although we acknowledge that many kernels involve more than one process.

< Insert Table 1 about Here >

Altering Consequences for Behavior

Increasing rate or probability of behavior. Many kernels increase behavior by mobilizing reinforcement for the targeted behavior. These include vocal praise, written praise notes, prize bowls, and public posting of feedback about the rate of a targeted behavior. Each delivers positive consequences contingent on a behavior. In the case of public posting of feedback, it is necessary that the recipients of posted information in some sense want to increase the behavior.

We put special play with parents in this category too. Special play involves adults letting the child lead in free play activities (Webster-Stratton & Reid, 2003). Its purpose is to facilitate interactions in which parents do not command, criticize, or unduly restrict activities of the child and allow the child to engage in fantasy play with the parent. Such interactions presumably are reinforcing for parent and child; the child received the undivided attention of the parent contingent on cooperative play, and the parent experiences cooperative and pleasant interactions with the child contingent on listening to the child and following the child's lead.

Decrease behavior by altering consequences. Other procedures alter consequences in order to decrease the frequency or probability of a behavior. Some involve ensuring that an undesirable behavior does not elicit reinforcement. Timeout is one such procedure. Rewarding behavior incompatible with the undesirable behavior is another.

A third set of procedures (ostensibly designed to decelerate behavior rates) involves delivering aversive consequences for a particular behavior. These traditionally are termed *punishment*. However, many so-called punishments (e.g., lengthy grounding of teens, mandatory minimum sentences) have no beneficial effect in reducing the subsequent likelihood of undesirable behavior. Our society uses such practices extensively, and there is substantial evidence of the harm of doing so (Sampson & Laub, 1994). Indeed, a major challenge for many parenting programs is getting parents to be less punitive. Aversive consequences can reduce unwanted behavior when children's behavior consistently causes the consequence. However, our society generally overuses aversive consequences, leading to deleterious side effects such as unwanted hyperarousal and avoidance of the change agent. Thus, in developing procedures that make aversive consequences contingent on behavior, we need to evaluate them carefully to ensure they are effective and have few side effects.

One example of a negative consequence affecting behavior is the use of fines. Agras et al. (1980) found that fines reduced water wastage among individuals but not among businesses. Fletcher (1995) found that fines for parking in spaces reserved for people with disabilities significantly decreased the behavior.

Altering Behavior through Antecedents

Many kernels work largely by establishing the functions of antecedents to behavior. A common example in schools is teachers establishing signals to guide transitions (Marion & Muza, 1998; Rosenkoetter & Fowler, 1986; West et al., 1995). For example, many teachers turn lights off and on to signal students to return to their seats and become quiet and attentive. Of course, positive consequences (e.g., praise) are involved in establishing effectiveness of the stimulus, but once established, the salient feature is the influence of the light on the behavior.

Assigning students meaningful roles (Rutter, 1981), such as setting up equipment for an assembly, taking roll, or taking photographs used to communicate desirable school activities are activities that organize useful behavior. Antecedents may also include organized playground activities to reduce aggressive behavior and occasion various social competencies (Murphy et al., 1983). Reinforcement follows naturally from the enactment of the role.

In general, it would be arbitrary to classify antecedent interventions based upon whether they increase or decrease behavior. This is because antecedents that prompt a desired behavior, at the same time make troublesome behavior less likely.

Altering Behavior by Influencing Relational Responding

Tradition within psychology suggests it is unfeasible to deal with cognitive and emotional influences on behavior within a basic behavioral framework of antecedents and consequences. However, recent work on relational frame theory (Hayes et al., 2001) has shown that human cognitive and verbal behavior can be understood in terms of basic operant processes. To the extent this is true, it provides a parsimonious account of complex human functioning within a contextualist framework focusing on manipulable behavior influences (Biglan & Hayes, 1996).

Research on relational responding. There is growing evidence that a fundamental feature of human cognitive or verbal processes is the relating of stimuli (Barnes et al., 2000). Because this analysis is a recent development and likely to be unfamiliar to most readers, we will elaborate it here. Barnes et al. (2000) present a theoretical analysis of human relational responding. According to this analysis, the core feature of verbal and cognitive behavior is the relating of stimuli. Perhaps the most rudimentary relational responding involves naming. At the beginning of learning language, young children learn to say names for objects and separately learn to orient to objects when they hear their names. Each response is operant behavior reinforced by consequences such as attention, praise, and gaining of an object. After multiple experiences of this sort, however, a child also learns that if an object has a name, the name also goes with the object. In other words, they become able to derive the *mutual entailment* of name to object and object to name. Further experiences like this enable children to derive relations that are more complex. For example, learning that a puppy is a kind of dog and that Buddy is a puppy, a child is able to derive that Buddy is a dog. This ability to derive relations between two stimuli based on their relations with a third stimulus is *combinatorial entailment.*

The third defining feature is the *transformation of function.* Humans' derivation of relations among stimuli can transform the functions of stimuli that participate in the relation. For example, discovering that one coin is worth more than another makes the coin more reinforcing. Learning that water has bacillus in it may have no impact on a child, but upon learning that a bacillus is a germ and that germs can you make you sick, a child's reaction to the water changes.

A fourth defining feature of relational responding is *arbitrary applicability.* Many of the relations we learn arise from physical relations among stimuli. For example, *smaller than* and *larger than* are based on the relative size of objects. However, humans become able to relate stimuli in these terms even though the stimuli do not have physical features involving relative size. If you find that one person has a bigger heart than another person does, you may expect that person to be kinder, even though you understand that his heart is not literally bigger.

For theorists accustomed to the panoply of existing cognitive constructs, which admittedly do a good job of predicting much human behavior, the value of this analysis may be obscure. Its value lies in providing a direct analysis of the specific procedures that influence relational responding and thereby transform the functions of stimuli.

Increasing behavior by altering relational responding. Perhaps the simplest and most important procedure of this type is to augment the value of stimuli by influencing people to relate them to stimuli they already value. If we tell children they can stay up a half hour more if they get five stickers, we change their valuing of the stickers. In essence, any procedures influencing people to relate a stimulus with stimuli they already value make that stimulus more reinforcing.

One example of this process is the introduction to the PeaceBuilders program (Embry et al., 1996). An adult asks group members to imagine what they would expect to see, hear, and feel more—and less—of in a peaceful home, school, or community. The discussion elicits suggestions of small actions such as hear/give compliments, withhold insults, etc. Then, the adult states that those who make these things happen are "PeaceBuilders." The adult then asks, "Who could be a PeaceBuilder?" The answer is "all or any of us." Next, children—and adults—receive prompts to ask, "What would a PeaceBuilder do?" or they learn to notice "PeaceBuilder behaviors" in each other. The process establishes the word PeaceBuilder as a valued concept and makes being a PeaceBuilder—and all behaviors later related to this concept—more reinforcing.

Another example is public commitment. When people publicly commit to engage in a behavior, they are more likely to follow through on the behavior (e.g., Burn & Oskamp, 1986).

Making a public commitment makes behavior inconsistent with that pledge increasingly aversive, due to expected disapproval for failing to act consistently with that commitment.

In self-modeling, a story is created about a person's behavior (Hosford, 1980); the person typically participates in the process. The story embeds a person's self in a set of relations with desired behaviors and attributes (e.g., depicting a child as a hero at school and home for helping bring about peaceful behaviors; Embry et al., 1996). Or, a child may learn a series of self-help skills through photographs or video (Hartley et al., 1998), making the child more likely to relate engaging in the behavior with valued ideas, such as being a "PeaceBuilder" (Embry et al., 1996)

Motivational interviewing (MI) may seem complex, yet we believe we cannot subdivide it into functionally active component parts without destroying its effects. In MI, the interviewer prompts a person to discuss a topic he or she generally avoids (e.g., the person's drinking patterns and difficulties associated with those patterns amid authentic goals the person articulates; Bernstein et al., 2005; McCambridge & Strang, 2004; Miller et al., 1988). The interviewer remains warm and accepting as the person talks, but asks questions designed to put the person in psychological contact with negative consequences of their behavior and the possible benefits of changing their behavior. It is clear that this process has reinforcing and antecedent features, but the most salient aspect of the process seems to be that it alters the way people relate their problematic behavior to negative consequences and possible alternatives to more reinforcing consequences. In other words, MI changes people's networks of relations in ways that make some behaviors more desirable and other behaviors less desirable.

Decreasing behavior by altering relational responding. Some behavior-influence procedures discourage behavior by prompting a person to relate the behavior to aversive stimuli. In general, any procedure prompting someone to relate undesirable behavior to negatively valenced stimuli would qualify as such a procedure—*provided there was empirical evidence of its effect.* For example, media associating drug use with negative outcomes have sometimes been shown to reduce drug use (Palmgreen et al., 1995), although no adequate evidence communicates that cigarettes' harmful health effects on teens can deter smoking. Yet, a relational frame suggesting that youth will receive immediate social rejection from peers does affect their tobacco use (Pechmann & Knight, 2002; Pechmann et al., 2003). This discrepancy stresses the need for research to refine our understanding of how and when persuasive communications alter people's relational networks about targeted behaviors and thereby affect the probability of behavior.

Physiological Interventions

Finally, some procedures affect behavior primarily physiologically. For centuries, humans altered their health and mood by manipulating physiological states. Anthropological and archeological literature is replete with examples (Spindler 1995; Lalramnghinglova, 1999; Rajan et al. 2002; Rodrigues, 2006). Hunters and gatherers often consume plants with stimulant properties, apparently because it confers an advantage during tasks such as hunting, which require sustained effort and attention. Modern humans have similar reasons for using caffeine.

The impact of Omega 3 fatty acid is a particularly important example of a physiological kernel (Olafsdottir et al., 2005). Aside from epidemiological research on the relationships of Omega 3 fatty-acid (n3) to a wide variety of causes of morbidity and mortality (Hibbeln, 2001), experimental and quasi-experimental studies find supplementation of Omega 3 reduces violent aggression among men (Gesch et al., 2002). Its use also reduces depression or bipolar disorder (Mischoulon & Fava, 2000; Stoll et al., 1999; Sund et al., 2003) and other health or public health concerns, such as low birth weight and offspring IQ (Helland et al., 2003). Although not yet

proven, Omega 3 may even alleviate some of the problems that have been associated with poverty, since poorer people have diets lower in Omega 3 (Egeland et al., 2001; Liu et al., 2004).

Other interventions that seem to affect behavior through direct impact on physiology including deep breathing, shown to reduce anxiety, arousal, and aggression among all ages (Appels et al., 1997; DiFilippo & Overholser, 1999; Peck et al., 2005; Sharma et al., 2005; Suzuki et al., 2000). Zinc supplementation may reduce or moderate ADHD symptoms (Arnold et al., 2005; Bilici et al., 2004). We include "rough and tumble" play, as it has been shown to reduce children's aggressive behavior (Bjorklund & Brown, 1998; Paquette, 2004; Pellegrini, 1992; Shannon et al., 2002) and the mechanism appears to involve alteration of brain chemistry (Panksepp et al., 2003; Siviy et al., 1996; Taylor et al., 1986).

The distinction between biological and environmental interventions is not absolute. Certainly, any environmental manipulation impacts biological functioning. Here we refer to interventions with their influence apparently through direct-manipulation biological processes as opposed to those that work through those traditionally called behavioral or psychological. Note we have excluded pharmacotherapy. Although pharmacological agents may alter behavior and meet our definition, the substantial literature on these influences merits separate discussion.

Prevention scientists, oriented toward the implementation of programs, may overlook physiological interventions. Publications about these kernels are not in journals devoted to behavioral science but more likely to appear in medical, public health, or specialty journals. However, the evidence for them suggests that treatment and prevention scientists should pay greater attention to the reciprocal relationships between physiology and behaviors.

Empirical Evidence Supporting Kernels

We define kernels as procedures empirically shown to affect a behavior. Following the Society for Prevention Research Standards of Evidence (Flay et al., 2004), our criteria for empirical support include randomized controlled trials and interrupted time-series designs in which a procedure's impact is evaluated on a repeated measure of target behavior. Most kernels have been evaluated via interrupted time-series designs, although some, such as Omega 3 impact, have been mostly in randomized trials. Some evaluated kernels using both methodologies.

Many kernels result from interplay between basic and applied research. Variable interval contingency management kernels (e.g., Mystery Motivator, Prize Bowl) have roots in animal lab research (Ferster & Skinner, 1957), then with humans (Majovski & Clement, 1977). This was followed by clinical studies using interrupted time series (Henderson et al., 1986; Leibowitz, 1975; Libb et al., 1973; Madaus et al., 2003; Moore et al., 1994; Robinson & Sheridan, 2000; Snell & Cole, 1976) and then by formal, randomized control trials (Petry et al., 2004; 2005).

Physiological kernels have a similar scientific trajectory. For example, the understanding of Omega 3 (n-3) has roots in early epidemiological or forensic inquiries showing differences among individuals with diseases or disorders (Anderson & Connor, 1989; Gudbjarnason et al., 1991; Lieber et al., 1969; Rudin, 1981). Initial epidemiological findings (Hibbeln, 1998; 2001; 2002) prompted precision-oriented laboratory studies (Hibbeln et al., 1998; Hibbeln & Salem, 1995) and larger epidemiological inquiries. All this work led to clinical trials evaluating Omega 3 supplementation (Nemets et al., 2002; Sund et al., 2003; Zanarini & Frankenburg, 2003).

Dominant use of interrupted time-series designs in developing kernels deserves further comment. It reflects not only an arbitrary methodological preference but an incremental, inductive, bottom-up strategy to build effective behavior influence practices. Kernels are of

necessity simple steps targeting a behavior one can easily measure repeatedly. It is thus easy to implement interrupted time-series designs. Single-subject studies are quite robust in terms of reducing threats to validity (Sidman, 1960) and in answering questions of whether a particular medication, procedure, or process is efficacious in changing a person or small group of persons (e.g., family, classroom, organization; Dadds et al., 1984; Greenwood & Matyas, 1990; Mayer et al., 1983; McGrath et al., 1987; Reagles & O'Neill, 1977). Such interrupted time-series designs are not limited to evaluating individuals but are often the experimental design of choice for evaluating policy impact on large or important social issues (Briscoe et al., 1975; Geller, 1973; Hayes & Cone, 1977; Wagenaar et al., 1988). Interrupted time-series designs can be effectively summarized via effect sizes and meta-analyses (Campbell, 2004; Stage & Quiroz, 1997).

Prevention and treatment research increasingly focuses on randomized trials, which is appropriate, given the need to determine effect sizes and generalizability of interventions developed thus far. Yet, there is no doubt room to improve the efficacy of our interventions (Biglan et al., 2006). Kernels are one source for strengthening those interventions. More generally, the success of the single case, experimental, and incremental strategy that has led to most existing kernels suggests that expanded use of this strategy in situations involving behavior influence could lead to steady improvement in our ability to influence successful development. Such a strategy would be similar to the continuous quality improvement strategy developed by Deming (1982) and adopted with such success by the Japanese auto industry (Halberstam, 1986).

An important limitation on current understanding about kernels is that we have relatively little information about situations in which they will be effective and those in which they will not be effective. Further research should explore the range of situations in which given kernels work and seek to develop a theory of the relationship between situations and the efficacy of kernels.

The Utility of Kernels

Disseminating Effective Behavior Influence Practices

If our ultimate public health goal is to minimize the prevalence of behavioral and psychological problems and improve wellbeing, then increasing the prevalence of effective behavior influence practices is essential. Disseminating kernels will be an important supplement to current reliance on program dissemination for achieving this outcome.

Efforts to increase the use of complex evidence-based programs through mandates and training have not yielded many benefits (Hallfors & Godette, 2002; Hallfors & Iritani, 2002), and coercion to use them often generates counter-control (Sidman, 1999; Unnever et al., 2004). By contrast, it is possible to disseminate kernels more readily than to disseminate multicomponent programs. Kernels have most features Rogers (1995) identified as important in fostering dissemination. He observed that people are more likely to adopt and implement a practice that is simple and easily tested, its effects readily observed, it appears to offer an advantage over existing practices, and it addresses an important problem compatibly with existing practices.

Most kernels are quite simple, consisting of an easily tested, low-cost activity. Moreover, it is usually possible to observe their immediate impact on a person’s behavior; it does not require statistical analysis of groups of individuals. As a result, the person who tries a kernel is likely to observe immediate benefit, which will likely reinforce its use. Finally, exhibited by the examples of kernels we provide, most affect behaviors important to change agents.

In addition, as noted above, even if empirically supported programs were widely disseminated, the vast majority of behavior-influence interactions in society would fall outside the scope of existing programs. For example, programs may teach social competencies to avoid aggressive behavior (Taylor et al., 1999) but cooperative games (e.g., Murphy et al., 1983) can structure student interactions in ways that minimize prompts to engage in aggression. If kernels were widely disseminated to behavior-influence agents (e.g., teachers, therapists, youth leaders, human service workers, and parents), it could result in effective behavior support practices being much more widely used than if we waited for these agents to generalize good practices from programs in which they were trained to use in specific situations.

Glasgow et al. (1999) proposed the RE-AIM framework for thinking about the long-term public health effects of interventions. They point out that the benefit of practices is a function of their *Reach* times *Efficacy* of the practices. However, even an intervention with the potential to reach many and be quite efficacious will have limited impact over time, unless it is *Adopted, Implemented*, and *Maintained.* We believe kernels provide important supplements to dissemination strategies because their readily observed benefits (efficacy) make them likely for adoption and maintenance and because they will substantially increase the reach of beneficial behavior influence practices because so many kernels are appropriate to so many situations.

Comparison of behavioral parenting skills training programs with a strategy of disseminating behavior influence skills to parents may help to illustrate this point. Behavioral parenting skills programs are largely composed of kernels, for example, timeout, praise, and special play. Parents who go through such programs learn a number of important behavior influence strategies. However, the reach of these programs is quite limited, because of their cost to administer and the cost in time and money to participants. The media version of Triple-P (Sanders et al., 2000) reflects the recognition that a population-based impact may be greater if large numbers of parents can be reached with specific kernels of effective parenting practice.

In sum, in addition to empirically supported programs coming into wider use, we foresee the spread of kernels into the repertoires of many change agents in situations for which no programs have been designed.

Reducing the Cost of Beneficially Influencing Behavior

Evidence-based programs tend to be costly. The National Registry of Effective Programs and Practices (http://modelprograms.samhsa.gov/template.cfm?page=nrepbutton) provides cost information. Typical direct costs for program developers include material production, training, licensing, continuing consultation to adopters, monitoring of results, and program improvement. Then, there are "hidden costs" such as venues, staff time for training, temporary staff replacement to cover duties, and administrative costs. For example, a model universal program that reduced observed aggression on the playground by about 10% (Grossman et al., 1997) requires 17.5 hours of direct instruction per pupil, plus indirect costs for material and training of teachers. Thus, a school with 25 teachers may have to spend $12,000 to $15,000 for materials, staff training, staff timing, and (possibly) substitute teachers. A cost of $500 per teacher per universal program is unexceptional. Therapeutic model programs (e.g., Ogden & Halliday-Boykins, 2004; Szapocznik & Williams, 2000) can cost between $80,000 and $200,000 depending on the nature of licensing requirements, training, materials, supervision, monitoring, and staffing. If multiple evidence-based programs are required, costs per problem (e.g., tobacco, alcohol, violence, bullying, or mental illness) can bring the total to hundreds of thousands of

dollars in direct and indirect costs per setting. These funds are not typically available to schools, human service agencies, groups and others charged with prevention and treatment. There is no reason to expect that there will be a surge in such funds at a local, state, or federal level anytime soon. Clearly, if program adoption is the only avenue to large population effects, progress will be slow and costly.

Kernels provide a low cost alternative to the program dissemination strategy. Because most kernels are simple, written descriptions or videos can readily aid their dissemination. Because all are in the public domain, they are available without charge, in mass media or via the worldwide web. Indeed, as described above, we have begun a website that describes kernels and invites others to register kernels.

The fact that kernels are in the public domain discourages certain types of profit-motivated dissemination. For example, despite strong evidence of its efficacy for diverse problems, a pharmaceutical company would have little incentive to market Omega 3 (fish oil) for the treatment of bipolar disorder, post-partum depression, depression, developmental disabilities, or aggression.

There are, however, viable business models that would motivate dissemination of kernels. It is possible to make access to information about kernels a commodity sold on the Internet at low cost. Indeed, video's modeling kernels could be available through iTunes, amazon.com, or e-bay. Alternatively, some kernels could be available at drug stores, supermarkets, or other natural venues or "places" as the social marketing literature phrases access. Small businesses and other employers, local governments, and other potential beneficiaries of kernels might well become bulk purchasers or distributors of kernels that have an impact on health, safety, competitiveness, bottom-line, and other important outcomes. Kernels appear to favor a potential mass rather than limited "boutique" market for prevention and treatment, which is a relatively new concept for behavioral scientists. A recent randomized comparison study of treatments for methamphetamine addiction, a notoriously difficult problem plaguing many states and localities during the last decade, highlights this potential. The study compared treatment as usual, the MATRIX Model (an evidence-based program) and a simple contingency management kernel that involved rewards for "clean" urine samples (Rawson et al., 2006). The study showed that the evidence-based kernel, which is quite low cost in terms of staffing, training, and funds had better or equal results to the evidence-based program developed by the same scientists and collaborators (Obert et al., 2000).

Improving the Effectiveness of Prevention and Treatment Practice and Theory

Our analysis of kernels points to a number of ways that research and practice of prevention and treatment could gain strength. First, we hope to facilitate the analysis of existing empirically supported programs. We can examine programs to identify components that are kernels and then point to ways in which adding kernels could strengthen existing programs.

Second, the analysis makes it possible to construct new interventions by putting together a set of kernels that all appear relevant and useful for the behavior influence situation that the change agent is dealing with. Of course, researchers who would submit such programs to evaluation via randomized trials could do this, but practitioners could also do it. The practitioners may not have the wherewithal to evaluate thoroughly a program they create. However, since the kernels have already undergone evaluation, the practitioners could have greater confidence in the efficacy of the program.

Third, our theoretical analysis of kernels also may help to develop new kernels. In essence, the framework suggests that, in any instance requiring altered behavior, it will pay to examine systematically if it is possible to alter consequences or antecedents for the behavior, if it is possible to influence relational responding in ways that change the value of relevant behaviors, and finally, whether physiological interventions could alter the probability of behavior. A thorough understanding of existing kernels would contribute to the success of this effort.

Fourth, prevention and treatment scientists could do a great service by mapping kernels onto risk and protective factors. There is a large amount of literature on the relationships between risk and protective factors and problematic outcomes. For instance, much research points to early antisocial behavior, school bonding, and inadequate parental monitoring as predictors of various adverse outcomes (Arthur et al., 2002; Dekovic, 1999; Duncan et al., 2000). A problem is that many of these risk factors are not actionable in clear ways. For example, although the risk and protective literature suggest that "school bonding" and perceived opportunities for prosocial involvement are important targets, this evidence, by itself, does not point to specific strategies for altering either construct. At the same time, there are kernels from the scientific literature that do seem to affect these constructs. Examples include the percentage of students with meaningful roles in a day, the square footage of student work displayed on the walls, the number of peer-to-peer positive written notes, the caught-you-being good notes, or positive notes home (Embry, 1997; Embry et al., 1996; Lewis et al., 1998; Mayer et al., 1983; Rutter, 1981). Articulating the kernels relevant to each risk or protective factor would provide practitioners with more precise guidance as to which kernels are most useful for altering key risk and protective factors. It could support efforts to influence behavior such as the health behavior goals specified by Healthy People 2010 (http://www.healthypeople.gov/).

Fifth, identifying kernel-like practices may foster the diffusion of beneficial behavior influence practices in society. This has already happened in some cases, such as with Omega 3. Epidemiological studies show that proxy measures of Omega 3 consumption predict many important prevention and treatment outcomes such as reductions in cardiovascular diseases, depression, and homicide across or within nations (Hibbeln, 2001, 2002; Hibbeln et al., 2006; McGrath-Hanna et al., 2003; Tanskanen et al., 2001). At the same time, intervention studies show that such changes in the consumption of Omega 3 have clear benefit in reducing these types of adverse conditions (Freeman et al., 2006; Gesch et al., 2002). We urge that epidemiologists use existing evidence about kernels to examine whether kernels are occurring naturally in social systems and are benefiting the populations. Such research would strengthen the link between epidemiology and intervention research and practice, at the same time that it strengthened empirically based theory about human development.

A Database Repository of Kernels

In the interest of fostering the dissemination and further development of kernels, we have initiated a database repository of kernels (http://www.earlyadolescence.org). It contains the kernels listed in Table 1 and enables people to describe additional kernels and the empirical evidence regarding their effects. The database allows the user to search for specific kernels or to identify a behavior and search for kernels that are relevant to influencing the behavior. We are hopeful that this repository will provide detailed information about how kernels influence behavior, the circumstances in which they work or do not work, iatrogenic effects, potential combinations, variations of kernels related to cultures or other establishing conditions, and

proximal and distal behavioral effects. In time, the database will have hyperlinks to citations in PsychInfo or PubMed. We expect that this repository of kernels will help to reduce the cost of beneficially influencing behavior as well as in improving the efficacy of prevention and treatment practice and theory.

Summary

Kernels are fundamental units of behavior-influence technology. They provide a wealth of resources for those who are trying to influence human behavior in beneficial ways. The four primary mechanisms of kernels are providing consequences for behavior, establishing antecedent stimuli for behavior, altering people's relational framing about targeted behaviors, and altering physiology that affects behavior. Understanding the range and effectiveness of kernels could contribute to the public health goals of decreasing the prevalence of problems and increasing wellbeing. It could provide behavior influence agents with a wider array of effective practices. It could clarify the active components of existing programs. It could lead to the development of new programs that are composed entirely of effective kernels. Finally, it could contribute to the development of an empirically based theory of behavior influence that is consistent with current knowledge of risk and protective factors and clarifies the mechanisms through which behavior influence occurs.

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Table 1: Example taxonomy of potential kernels			
Kernel Example	**Description**	**Behaviors Affected**	**Evidence**
Kernels Altering Consequences for Behavior			
Kernels increasing frequency of behavior			
Verbal praise	Person or group receives spoken (or signed) recognition for engagement in target acts, which may be descriptive or simple acknowledgements	Cooperation, social competence, academic engagement/achieve-ment, positive parent-child interactions, positive marital relations, better sales; reduced disruptive or aggressive behavior; reduced DSM-IV symptoms	Leblanc, Ricciardi, & Luiselli, 2005; Lowe & McLaughlin, 1974; Marchant & Young, 2001; Marchant, Young, & West, 2004; Martens, Hiralall, & Bradley, 1997; Matheson & Shriver, 2005; Robinson & Robinson, 1979; Scott, Spender, Doolan, Jacobs, & Aspland, 2001
Peer-to-peer written praise: "Tootle" notes, compliments books/ praise notes	A pad or display of decorative notes is posted on a wall, read aloud, or placed in a photo album where peers praise behaviors	Social competence, academic achievement, work performance, violence, aggression, physical health, vandalism	Cabello & Terrell, 1994; Embry et al., 1996; Farber & Mayer, 1972; Heap & Emerson, 1989; Mayer et al., 1983; 1993; Skinner et al., 2000
Beat the timer or beat the buzzer	Reduced time set to complete a task, with access to reward or recognition if task successfully completed before time interval	Parent-child interactions, compliance, physical abuse, child aggression, ADHD, work completion, academic accuracy	Adams & Drabman, 1995; Ball & Irwin, 1976; Drabman & Creedon, 1979; Hudson et al., 1985; Luiselli & Greenidge, 1982; McGrath et al., 1987; Wolfe et al., 1981; Wurtele & Drabman, 1984
Mystery motivators/ grab bag/prize bowl/ game of life	Person draws variable prize of higher and lower values for engaging in targeted behavior	Conduct disorders, oppositional defiance, ADHD, substance abuse, work performance	De Martini-Scully, 2000; Madaus, Kehle et al., 2003; Madaus et al., 2003; Moore et al., 1994; Petry et al., 2000; Petry et al., 2001; Petry et al., 2005; Petry & Simcic, 2002; Petry et al., 2004; Petry et al., 2001; Robinson & Sheridan, 2000
Public posting (graphing) of feedback of a targeted behavior	Results or products of activity posted for all, which may be scores of individuals, teams or simply display of work product for all to see.	Speeding, academic achievement, conservation, donations, community participation, injury control	Parsons, 1982; 1992; Jackson & Mathews, 1995; Whyte et al., 1983; Ragnarsson & Bjoergvinsson, 1991; Nordstrom et al., 1990; Van Houen & Nau, 1981; Nicol & Hantaula, 2001

Table 1: Example taxonomy of potential kernels			
Kernel Example	**Description**	**Behaviors Affected**	**Evidence**
Principal lottery	Tokens or symbolic rewards for positive behavior result in random rewards from status person (e.g., principal, authority figures) such as positive phone calls home	Academic achievement, disruptive behavior, aggression	Thorpe, Darch, & Drecktrah, 1978; Thorpe, Drecktrah, & Darch, 1979
Safety or performance lottery	Tokens or reward tickets given for observed safety or performance behavior, then entered into lottery	Safety behaviors, accident reduction, improved sales or work performance	Geller, Johnson, & Pelton, 1982; Putnam, Handler, Ramirez-Platt, & Luiselli, 2003; Roberts & Fanurik, 1986; Saari & Latham, 1982
Contingent music	Music played or stopped in real time, based on observed behavior of the individual or group.	Increased weight gain of babies, improved baby development possibly, work performance, academic achievement, attention and focus (ADHD symptoms down); reduced aggression	Allen & Bryant, 1985; Barmann & Croyle-Barmann, 1980; Barmann et al., 1980; Bellamy & Sontag, 1973; Blumenfeld & Eisenfeld, 2006; Cevasco & Grant, 2005; Cook & Freethy, 1973; Cotter, 1971; Davis et al., 1980; Dellatan, 2003; Deutsch et al., 1976; Eisenstein, 1974; Harding & Ballard, 1982; Hill et al., 1989; Holloway, 1980; Hume & Crossman, 1992; Jorgenson, 1974; Larson & Ayllon, 1990; Madsen, 1982; McCarty et al., 1978; McLaughlin & Helm, 1993; Standley, 1996, 1999; Wilson, 1976; Wolfe, 1982
Team competition	Groups compete on some task, performance, or game.	Improved academic engagement and achievement, reduced disruptive behavior, increased sales, increased funding raising, increased safety; reduced smoking; changed brain chemistry favoring attention and endurance	Beersma et al., 2003; Hoigaard, Safvenbom, & Tonnessen, 2006; Kivlighan & Granger, 2006; Koffman, Lee, Hopp, & Emont, 1998; Neave & Wolfson, 2003; Tingstrom et al., 2006
Special play	Adult (caregiver or teacher) plays with the child, but lets the child take the lead in determining what games will be played and how.	Improved stress physiology, compliance, and social competence; reduced trauma or depressive symptoms	Bratton, Ray, Rhine, & Jones, 2005

Table 1: Example taxonomy of potential kernels			
Kernel Example	**Description**	**Behaviors Affected**	**Evidence**
Choral responding	Person(s) chant (or sign) answer to oral or visual prompt in unison; praise or correction follows	Compared to handraising, improved academic achievement, disruptive symptoms, retention; reduced behavior problems	Godfrey et al., 2003; Kamps et al., 1994; Taubman et al., 2001; Wolery et al., 1992
Mystery shopper	Unknown individuals make "purchase" or "help request", and target receives praise, reinforcement or corrective feedback	Reduced tobacco sales; improved customer relations; better sales, better compliance by pharmacists, better service from medical personnel or prevention personnel	Bennett, Petraitis, D'Anella, & Marcella, 2003; Borfitz, ; Krevor, Capitman, Oblak, Cannon, & Ruwe, 2003; Lowndes & Dawes, 2001; Moore, 1984; Norris, 2002; Saunders, 2005; Steiner, 1986; Sykes & O'Sullivan, 2006
Peer-to-peer tutoring	Dyad or triad take turns asking questions, give praise or points and corrective feedback	Improved academics, reduced ADHD/conduct problems, long-term effects on school engagement decreased special educ needs.	Allsopp, 1997; Delquadri et al., 1983; DuPaul et al., 1998; Fantuzzo & Ginsburg-Block, 1998; Greenwood, 1991a, b; Maheady et al.,1988a, b; Sideridis et al., 1997
Computer action game	Motor response to hit target or get right answer; visual/auditory feedback for correct response, with scoreboard	Increased attention and reduced ADHD like symptoms, which is associated with release of dopamine in the brain	Aase & Sagvolden, 2006; Ford, Poe, & Cox, 1993; Green & Bavelier, 2003; Koepp et al., 1998; Silva, 1999
Correspondence training, "Say-Do"	Symbolic or live models typically represented with a language frame; others elicit what individual says will do and reinforcement follows	Increased rates of targeted behaviors such as academic engagement, disturbing behavior or self-care behaviors	Anderson & Merrett, 1997; Luciano, Herruzo, & Barnes-Holmes, 2001; Luciano-Soriano, Molina-Cobos, & Gomez-Becerra, 2000
Correspondence training, "Do-Say"	Symbolic or live models typically presented. Cues for behavior and reports by individual to others followed by praise/reinforcement.	Increased rates of targeted behaviors such as academics, self-care or other developmental/life skill tasks	Merrett & Merrett, 1997; Morrison, Sainato, Benchaaban, & Endo, 2002; Roca & Gross, 1996
Kernels decreasing frequency of behavior			
Time out	Using timer, remove from natural reinforcement for 1 minute plus 1 minute for each year of age	Decreases non-compliance, argumentative behavior and mood outbursts	Fabiano et al., 2004; Kazdin, 1980; Wolf et al., 1967

Table 1: Example taxonomy of potential kernels

Kernel Example	Description	Behaviors Affected	Evidence
Sit and watch, contingent observation or response lock out	Very brief removal from reinforcement (2 minutes or less), with high density reinforcement upon reentry for desired behavior	Reduces disruptions in classroom, aggression on playground or during physical education, reduces dangerous behavior	Embry, 1982, 1984; Murphy et al., 1983; Porterfield, Herbert-Jackson, & Risley, 1976; White & Bailey, 1990
Taxation on consumptive behaviors	Percentage of purchase price of goods such as cigarettes, alcohol and luxury goods	Increasing taxation on liquor or tobacco reduces consumption	Biglan et al., 2004
Positive note home for inhibition	Adult sends home positive note for inhibition that results in home reward	Reduces disruptive and aggressive behavior and problems at home; increases engagement at school	Gupta, Stringer, & Meakin, 1990; Hutton, 1983; Kelley, Carper, Witt, & Elliott, 1988; McCain & Kelley, 1993; Taylor, Cornwell, & Riley, 1984
Timed rewards for inhibition (DRO)	Using fixed or variable interval, person receives praise and reward for not engaging in a behavior.	Reduces ADHD symptoms, conduct problems, accidental attention to negative; increases engagement in prosocial activities	Conyers, Miltenberger, Romaniuk, Kopp, & Himle, 2003; Conyers et al., 2004; Hegel & Ferguson, 2000
Premack Principle	The opportunity to engage in a high-probability behavior is made contingent engaging in a targeted behavior or on the inhibition of problematic behavior	Decreases ADHD like behavior, inattention, disruptive behavior, non-compliance	Agathon & Granjus, 1976; Andrews, 1970; Browder et al., 1984; Ghosh & Chattopadhyay, 1993; Gonzalez & Ribes, 1975; Harrison & Schaeffer, 1975; Homme et al., 1963; Hosie et al., 1974; Knapp, 1976; Leclerc & Thurston, 2003; Mazur, 1975; McMorrow et al., 1978; Van Hevel & Hawkins, 1974; Welsh et al. 1992; Williamson, 1984
Response-cost (point loss)	Small symbolic reward removed or debited, non-emotionally, quickly following targeted behavior	Decreases inattention and disruption; decreases ADHD like behaviors; may if used as a part of teams in first grade decrease substance abuse over lifetime	Conyers et al., 2004; Filcheck et al., 2004; Furr-Holden et al., 2004; Jason et al., 2005; Jorgensen & Pedersen, 2005; Kellam & Anthony, 1998; Kelley & McCain, 1995; McGoey & DuPaul, 2000; Storr et al., 2002

Table 1: Example taxonomy of potential kernels			
Kernel Example	**Description**	**Behaviors Affected**	**Evidence**
Low emotion or "private" reprimands	Corrective feedback given without biological cues of threat or intense emotion; short rather than long reprimands are typically of more effective ones	Reduces inattention, disruptions, aggression; reduces emotional responding by adults, including attention to negative behavior	Abramowitz et al., 1987; 1988; Acker & O'Leary, 1987; Harris et al., 2003; Houghton et al., 1990; Maglieri et al., 2000; Merrett & Tang, 1994; Ostrower & Ziv, 1982; Pfiffner et al., 1985; Piazza et al., 1999; Rolider & Van Houten, 1984; Scholer et al., 2006; Van Houten et al., 1982
Stop clock	Clock is triggered when students misbehave. Lower times on the clock result in access to rewards	Increased academic engagement and reduced disruptions	Cowen, Jones, & Bellack, 1979
Law enforcement fine or citation	Fine or ticket given for relatively minor non-compliant behavior	Reduces tobacco possession, illegal water use, parking in handicap spots	Agras etal., 1980; deWaard & Rooijers, 1994; Fletcher, 1995; Jason etal., 2000; 2005; Jorgensen & Pedersen, 2005; Liberman etal., 1975
Over-correction or Positive Practice	Person repeats restorative or correct behavior many times	Reduces symptoms of developmental delay; reduces aggression or noncompliance; may reduce accidental attention to negative behavior	Carey & Bucher, 1986; Foxx & Jones, 1978; Lennox et al., 1988; Maag et al., 1986; Singh, 1987; Singh & Singh, 1988; Sisson et al., 1993; Sumner et al., 1974; Watson, 1993
"Buzzer/Noise Training"	A buzzer or noxious noise happens upon some undesired behavior	Reduces non seatbelt use, bedwetting, walking through unauthorized door or driving on shoulder of road	Ankjaer-Jensen & Sejr, 1994; Collins, 1973; Crisp et al., 1984; Hirasing & Reus, 1991; Meadow, 1977; Robertson, 1975; Robertson & Haddon, 1974
Kernels Affecting Behaviors Primarily Via Antecedents			
Non-verbal transition cues	Combinations of visual, kinesthetic and/or auditory cues that single shifting attention or task in patterned way, coupled with praise or occasional rewards.	Reduces dawdling, increases time on task or engaged learning; gives more time for instruction	Rosenkoetter, & Fowler, 1986; Krantz, & Risley, 1977; Abbott et al., 1998; Embry et al., 1996

Table 1: Example taxonomy of potential kernels

Kernel Example	Description	Behaviors Affected	Evidence
Stop lights in school settings or traffic settings	Traffic light signals when behavior is appropriate/desirable or inappropriate/undesirable in real time, and connected to some kind of occasional reinforcement.	Decreases noise, off task behavior, or increases stopping in dangerous intersections	Cox, Cox, & Cox, 2000; Jason & Liotta, 1982; Jason et al., 1985; Lawshe, 1940; Medland & Stachnik, 1972; Van Houten & Malenfant, 1992; Van Houten & Retting, 2001; Wasserman, 1977
Boundary cues and railings	These may be lines or other cues such as ropes or rails that signal where behavior is safe, acceptable or desired	Decreases dangerous behavior; decreases pushing and shoving; increases waiting behavior in a queue; reduces falls	Carlsson & Lundkvist, 1992; Erkal & Safak, 2006; Marshall et al., 2005; Nedas, Balcar, & Macy, 1982; Sorock, 1988
Cooperative, structured peer play	Planned activities during children playtime and involve rules, turn taking, social competencies, and cooperation with or without "soft competition."	Decreases aggression/increases social competence; affects BMI, seems to reduce ADHD symptoms and increase academics after; reduces social rejection in M.S.	Bay-Hinitz, Peterson, & Quilitch, 1994; Leff, Costigan, & Power, 2004; Mikami, Boucher, & Humphreys, 2005; Murphy et al., 1983; Ridgway et al., 2003
Self-modeling	Drawn, photographic, or video model viewer/listener engaging targeted behavior, receiving rewards or recognition.	Increases academic engagement; increases attention; increases recall and long term memory; improves behavior; reduces dangerous behavior; increases social competence; improved sports performance; reduced health problems	Barker & Jones, 2006; Ben Shalom, 2000; Bray & Kehle, 2001; Buggey, 2005; Clare et al., 2000; Clark et al., 1993; Clark et al., 1992; Clement, 1986; Davis, 1979; Dowrick, 1999; Dowrick et al., 2006; Elegbeleye, 1994; Hartley et al., 1998; Hartley et al., 2002; Hitchcock et al., 2004; Houlihan et al., 1995; Kahn et al., 1990; Kehle et al., 2002; Law & Ste-Marie, 2005; Lonnecker et al.,1994; Meharg & Lipsker, 1991; Meharg & Woltersdorf, 1990; Owusu-Bempah & Howitt, 1985; Owusu-Bempah & Howitt, 1983; Possell et al., 1999; Ram & McCullagh, 2003; Reamer et al., 1998; Rickards-Schlichting et al., 2004; Rickel & Fields, 1983; Schunk & Hanson, 1989; Schwartz et al., 1997; Walker & Clement, 1992; Wedel & Fowler, 1984; Woltersdorf, 1992

Table 1: Example taxonomy of potential kernels			
Kernel Example	**Description**	**Behaviors Affected**	**Evidence**
Self-monitoring	Coding target behavior with a relational frame, which is often charted or graphed for public or semi-public display, occasioning verbal praise from others	Reductions in alcohol, tobacco use; reductions in illness symptoms from diabetes; increased school achievement; changes in other social competencies or health behaviors; reductions in ADHD, Tourettes and other DSM-IV disorder; improvement in brain injured persons	Agran et al., 2005; Blick & Test, 1987; Boyle & Hughes, 1994; Brown & Frank, 1990; Buggey, 1995; Buggey et al., 1999; Burch et al., 1987; Carr & Punzo, 1993; Cavalier et al., 1997; Clare et al., 2000; Clarke et al., 2001; Dalton et al., 1999; de Haas-Warner, 1991; Foxx & Axelroth, 1983; Glasgow et al., 1983; Glasgow et al., 1983; Gray & Shelton, 1992; Hall & Zentall, 2000; Harris et al., 2005; Hertz & McLaughlin, 1990; Hitchcock et al., 2004; Hughes et al., 2002; Kern et al., 1994; Martella et al., 1993; Mathes & Bender, 1997; McCarl et al., 1991; McDougall & Brady, 1995; McLaughlin et al., 1985; Nakano, 1990; O'Reilly et al., 2002; Petscher & Bailey, 2006; Possell et al., 1999; Rock, 2005; Selznick & Savage, 2000; Shabani et al., 2001; Shimabukuro et al., 1999; Stecker et al., 1996; Thomas et al., 1971; Todd et al., 1999; Trammel et al.,1994; Winn et al., 2004; Wood et al., 1998; 2002
Paragraph shrinking	After hearing or seeing some content, person learns to “shrink” meaning to 8-10 words, full sentence; praise typically happens for good summaries.	Improved reading responses and retention	Bean & Steenwyk, 1984; Mathes et al., 1994; Spencer et al., 2003
Errorless discrimination training	Stimuli are faded or shaped in such a way that errors are nearly non-existent	Improved reading, letter recognition and life-task discriminations; reductions in symptoms of mental retardation or brain injury	Akhtar et al., 2006; Egeland & Winer, 1974; Etzel & LeBlanc, 1979; Fillingham et al., 2003; Hunkin et al., 1998; Keel & Gast, 1992; Lambert, 1979; Melchiori, Souza, & Rose, 1992; Plummer et al., 1977; Schilmoeller et al., 1979; Stawar, 1978; Terrace, 1969; Walsh & Lamberts, 1979

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Kernel Example	**Description**	**Behaviors Affected**	**Evidence**
Kernels Affecting Behaviors Primarily Via Relational Frames			
Adjectival noun for belonging to status group	Verbal phrase "I am/we _____" is paired with status, belonging, protection or safety	Increased rule governed behavior; increases behavior associated with the named group; decreases aggression within group; may affect physical health	Choenarom, Williams, & Hagerty, 2005; Embry et al., 1996; Gaskell & Smith, 1986; Juarez, 2002; Mishima, 2003
Public commitment	Individuals sign or pledge self to collective behavior	Voting, contributing money, recycling,	Burgess et al., 2000; Chen & Komorita, 1994; Wang & Katzev, 1990
"US" and "THEM" role framing	Individuals or groups are divided into two groups, with differences highlighted framed around clothing, adornment, language, social position, etc.	Increase aggression and violence by each group toward each other	Roos, 2005; Sherif, 1958, 1968, 1970; Sherif, Hogg, & Abrams, 2001; Sherif et al., 1955
Graphic/node maps	A graphic organizer for goal-based behavior, guided by other status individuals	Increased sobriety and goal completion; increased treatment compliance	Collier et al., 2001; Czuchry & Dansereau, 1996, 1999, 2003; Czuchry et al., 1995; Dansereau et al., 1995; Dansereau et al., 1993; Dees et al., 1994; Joe et al., 1997; Joe et al., 1994; Melville et al., 2004; Newbern et al., 2005; Newbern et al., 1999; Pitre et al., 1996; Pitre et al., 1998; Pitre et al., 1997
Motivational Interviewing	Oral questioning by status individual around major goals of target person with clarifying questions about interfering behavior	Reduction in substance abuse, increase in social competences and related goals; reduction in injuries or antisocial behaviors; increase in healthy behaviors	Bernstein et al., 2005; Burke, Arkowitz, & Menchola, 2003; Monti et al., 1999; Resnicow et al., 2001; Rusch & Corrigan, 2002; Smith, 2004; Sobell et al., 2003; Stein et al., 2006
Media associating behavior with *immediate* negative social outcomes	Media (TV, video, radio) showing behavior results in social rejection or escape from social rejection	Reduces sexually transmitted diseases; reduces alcohol, tobacco and other drug use	Beyth-Marom et al., 1993; Downs et al., 2004; Pechmann, 2001; Pechmann & Ratneshwar, 1994; Pechmann et al., 2003

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Kernel Example	**Description**	**Behaviors Affected**	**Evidence**
Kernels Affecting Behaviors Primarily Via Physiology			
Pleasant greeting with or without positive physical touch	Friendly physical and verbal gestures, on a frequent basis.	Affects donations; social status an perceptions of safety or harm; affects behavior streams of aggression, hostility or politeness	Edwards & Johnston, 1977; Ferguson, 1976; Field, 1999; Fry, 1987; Howard, 1990; la Greca & Santogrossi, 1980; Schloss et al., 1984
Massage, brushing or stroking	Any method of rubbing, stroking and therapeutic touch applied to the body	Reduces aggression, arousal, cortisol, depressive symptoms, PTSD symptoms, and pain	Diego et al., 2002; Field, Grizzle et al., 1996; Field et al., 1996; Field, Seligman et al., 1996; Field, 1998; Field, Grizzle et al., 1996; Jones, Field, & Davalos, 1998; Scafidi & Field, 1996
Turtle Technique	Using a turtle metaphor, child holds self, verbal frame, breaths through nose, and engage in sub-verbal or verbal self-coaching, with peer or adult reinforcement	Reduces arousal and aggression against peers or adults	Heffner, Greco, & Eifert, 2003; Robin, Schneider, & Dolnick, 1976
Omega3 fatty acid supplementation or increased fish consumption	1 gram to 3 grams taken orally per day; or fish consumption several times per week high in Omega 3	Reduces aggression, violence, depression, bipolar disorder, post partum depression and borderline personality disorder; early evidence for reducing symptoms of developmental disorders; and for reducing CVD and asthma	Fava, 2001; Freeman et al., 2006; Gesch et al., 2002; Hibbeln et al., 2006; Jarvinen et al., 2006; Mickleborough et al., 2006; Richardson, 2006; Stoll, Marangell, & Severus, 2000; Vaddadi, 2006; Zanarini & Frankenburg, 2003
Zinc supplementation or dietary consumption	15 mg per day eaten or supplemented	Evolving evidence finds the addition of zinc to the diet or by supplementation to increase the effectiveness of drug treatment and/or may prevent ADHD symptoms.	Akhondzadeh et al., 2004; Arnold et al., 2005; Arnold & DiSilvestro, 2005; Bilici et al., 2004; McGee et al., 1990; Sandyk, 1990

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Kernel Example	**Description**	**Behaviors Affected**	**Evidence**
"Rough and Tumble" Free Play with higher status conspecific	Several times per week child or adolescent engages in rough and tumble play, causing increased arousal and self-control mediated by status adult or peer	Reduces aggression, teaches self-control, may improve status among same-sex peers; changes c-fos gene expression in lab animals; the behavior may be especially important to the development of positive behavior among boys and unique contribution of fathering	Boulton & Smith, 1989; Gordon, Kollack-Walker, Akil, & Panksepp, 2002; Hines & Kaufman, 1994; Jacklin, DiPietro, & Maccoby, 1984; Paquette, 2004; Pellegrini & Smith, 1998; Reed & Brown, 2001; Scott & Panksepp, 2003
Aerobic play or behavior	Daily or many times per week child or adult engage running or similar aerobic solitary activities, game, or food gathering behavior	Reduces ADHD symptoms, reduces depression; reduces stress hormones; may increase cognitive function; decreases PTSD	Antunes et al., 2005; Atlantis et al., 2004; Berlin et al., 2006; Blue, 1979; Blumenthal et al., 2005; Crews et al., 2004; Doyne et al., 1983; Dunn et al., 2005; Dunn et al., 2001; Dustman & et al., 1984; Khatri et al., 2001; Kubesch et al., 2003; Manger & Motta, 2005; Marin & Menza, 2005; Phillips et al., 2003; Stein, 2005; Stella et al., 2005
Nasal breathing	When aroused, person breaths through nose, not mouth.	Reduces panic, anxiety and hostile mood; may improve cognitive function; changes core temperature of the limbic area	Backon, 1990; Block, Arnott, Quigley, & Lynch, 1989
Progressive muscle relaxation	Person tenses and relaxes sequence of muscles combined with anxiety evoking stimulus	Reduces panic, fear, anxiety; decreases negative attributions; decreases phobic responses with paired with evoking stimuli	Larsson et al., 2005; Norlander et al., 2005; Pawlow & Jones, 2005; Wencai et al., 2005